

WHAT IS CLAIMED IS:

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1. A method for fabricating an article from
an object material including an object fine surface
structure thereon having an object size, the method
10 comprising:

a first step of fabricating a first mold
from a first material, said first mold including a fine
surface structure corresponding to the object fine
surface structure and having a first size less than the
15 object size;

a second step of fabricating a second mold
by transferring the fine surface structure of the first
mold to a second material so that the fine surface
structure transferred to the second material has a
20 second size greater than the first size and less than
the object size;

a third step of fabricating the article by
transferring the fine surface structure of the second
mold to the object material so that the fine surface
25 structure transferred to the object material has the

object size.

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2. The method as claim in claim 1, wherein
the second step comprises:

a step of applying a first curable resin
onto the first mold to cover the fine surface structure
10 thereof, and pressing the second material against the
first mold with the first curable resin in between to
transfer the fine surface structure of the first mold
to the first curable resin;

a first curing step of curing at least a
15 portion of the first curable resin;

a first separating step of separating the
first curable resin from the first mold with the first
curable resin being bonded with the second material;
and

20 a first transferring step of transferring
the fine surface structure of the first curable resin
to the second material by dry-etching to form the
second mold; and

the third step comprises:

25 a step of applying a second curable resin

onto the second mold to cover the fine surface
structure thereof and pressing the object material
against the second mold with the second curable resin
in between to transfer the fine surface structure of
5 the second mold to the second curable resin;

a second curing step of curing at least a
portion of the second curable resin;

a second separating step of separating the
second curable resin from the second mold with the
10 second curable resin being bonded with the object
material; and

a second transferring step of transferring
the fine surface structure of the second curable resin
to the object material by dry-etching to form the
15 article.

20 3. The method as claimed in claim 2,
further comprising steps of:

performing a first de-molding treatment on
the first mold to facilitate separation of the first
curable resin from the first mold after the first step
25 and before the second step; and

performing a second de-molding treatment on the second mold to facilitate separation of the second curable resin from the second mold after the second step and before the third step.

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4. The method as claimed in claim 1,
10 wherein before the third step, the first step and the second step are repeated a plurality of times to fabricate a plurality of second molds.

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5. The method as claimed in claim 2,
wherein

the first transferring step includes a step
20 of changing a dry-etching selection ratio of etching the first curable resin and the second material; and

the second transferring step includes a step of changing a dry-etching selection ratio of etching the second curable resin and the object material.

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6. The method as claimed in claim 5,
5 wherein in each of the first transferring step and the
second transferring step, the dry-etching selection
ratio varies with time.

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7. The method as claimed in claim 2,
wherein
at least one of the first curable resin and
15 the second curable resin includes a light curable
resin; and
at least one of the first material and the
second material, and one of the second material and the
object material sandwiching the light curable resin,
20 include a light transmittable material, and the light
curable resin is cured in the first curing step and the
second curing step by irradiating light through the
light transmittable material.

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8. The method as claimed in claim 7,
wherein

5 the light curable resin is an ultraviolet
light curable resin; and

the light transmittable material is an
ultraviolet light transmittable material; and

the light curable resin is cured by
10 irradiating ultraviolet light through the ultraviolet
light transmittable material.

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9. The method as claimed in claim 2,
wherein at least one of the first material and the
second material includes silicon.

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10. The method as claimed in claim 1,
wherein

25 the first mold is made from a material

capable of being processed by dry-etching including one of a metallic material, a glass material, a ceramic material, a plastic material, and a hard rubber material; and

5 the fine surface structure of the first mold is formed by one of dry-etching and lithography.

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11. The method as claimed in claim 1, wherein the first mold is fabricated by forming the fine surface structure on a plate made from the first material.

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12. The method as claimed in claim 2, wherein the second transferring step includes a step of determining the second size of the fine surface structure of the second mold in such a way so as to include an amount of shrinkage of the second curable resin during the second curing step.

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13. The method as claimed in claim 3,
5 further comprising steps of:

performing a first surface treatment on the
surface of the first mold having the fine surface
structure to improve adhesion between the first curable
resin and the second material after the first de-
10 molding treatment and before the second step; and

performing a second surface treatment on the
surface of the second mold having the fine surface
structure to improve adhesion between the second
curable resin and the object material after the second
15 de-molding treatment and before the third step.

20 14. The method as claimed in claim 1,
wherein the first step comprises steps of:

applying a photo-conducting material onto a
surface of the first material;

irradiating light onto the photo-conducting
25 material using a mask having a light transmittance

distribution, and developing the photo-conducting material to form a predetermined pattern on the photo-conducting material; and

transferring the pattern on the mask to the
5 first material by dry-etching.

10 15. The method as claimed in claim 2,
wherein

the first step includes a step of forming a channel on the first mold for an uncured portion of the first curable resin surrounding the cured portion of
15 the first curable resin to flow in to fill in a space generated due to shrinkage of the first curable resin during curing; and

the second step includes a step of forming a channel on the second mold for the uncured portion of
20 the second curable resin surrounding the cured portion of the second curable resin to flow in to fill in a space generated due to shrinkage of the second curable resin during curing.

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16. A method for fabricating an article
from an object material including an object fine
5 surface structure having one or more elements, the
method comprising:

a first step of fabricating a surface
structure substrate by forming a preliminary surface
structure on the object material, said preliminary
10 surface structure having elements corresponding to the
elements of the object fine surface structure;

a second step of fabricating a mold from a
mold material, the mold including a fine surface
structure having elements equivalent to the elements of
15 the object fine surface structure in shape; and

a third step of fabricating the article by
transferring shapes of the elements of the fine surface
structure of the mold to the corresponding elements of
the preliminary surface structure on the surface
20 structure substrate to form the elements of the object
fine surface structure.

17. The method as claim in claim 16,
wherein in the first step, the preliminary surface
structure is formed by a method including at least one
of sandblasting, dry etching, wet etching, dicing,
5 polishing, cutting, sol-gel method, glass bonding, and
thin film formation including vacuum evaporation,
sputtering, and CVD (Chemical Vapor Deposition).

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18. The method as claim in claim 16,
wherein

the third step comprises:

15 a step of applying a curable resin onto the
mold to cover the fine surface structure thereof and
pressing the surface structure substrate against the
mold with the curable resin in between to transfer the
fine surface structure of the mold to the curable resin,
20 the elements of the fine surface structure of the mold
being aligned to the corresponding elements of the
preliminary surface structure on the surface structure
substrate;

a curing step of curing at least a portion
25 of the curable resin;

a separating step of separating the curable resin from the mold with the curable resin being bonded with the surface structure substrate; and

a transferring step of transferring the fine
5 surface structure of the curable resin to the surface structure substrate by dry-etching to form the article.

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19. The method as claimed in claim 18,
further comprising a step, after the second step and
before the third step, of performing a de-molding
treatment on a surface of the mold having the fine
15 surface structure to facilitate separation of the curable resin from the mold in the separating step.

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20. The method as claimed in claim 18,
wherein the transferring step includes a step of
changing a dry-etching selection ratio of etching the
curable resin and the object material.

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21. The method as claimed in claim 20,
5 wherein the dry-etching selection ratio varies with
time.

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22. The method as claimed in claim 18,
wherein
the curable resin includes a light curable
resin;

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at least one of the mold material and the
object material sandwiching the curable resin includes
a light transmittable material; and

the curable resin is cured in the curing
step by irradiating light through the light
20 transmittable material.

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23. The method as claimed in claim 22,

wherein

the light curable resin is an ultraviolet
light curable resin; and

the light transmittable material is an
5 ultraviolet light transmittable material; and

the light curable resin is cured by
irradiating ultraviolet light through the ultraviolet
light transmittable material.

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24. The method as claimed in claim 16,
wherein

15 the mold is made from a material capable of
being processed by dry-etching; and

the fine surface structure of the mold is
formed by one of dry-etching and lithography.

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25. The method as claimed in claim 16,
wherein the mold is fabricated by forming the fine
25 surface structure on a plate made from the mold

material.

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26. The method as claimed in claim 18,
wherein a size of the fine surface structure of the
mold is determined to include an amount of shrinkage of
the curable resin during the curing step.

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27. The method as claimed in claim 19,
15 further comprising a step, after the de-molding
treatment and before the third step, of performing a
surface treatment on the surface of the mold having the
fine surface structure to improve adhesion between the
curable resin and the object material.

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28. A method of fabricating a mold,
25 comprising steps of:

applying a photo-conducting material onto a surface of a mold material;

irradiating light onto the photo-conducting material using a mask having a light transmittance distribution, and developing the photo-conducting material to form a predetermined pattern on the photo-conducting material; and

transferring the pattern to the mold material by dry-etching.

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29. A method of fabricating a mold from a mold material for transferring thereto a shape on a primary mold, the method comprising steps of:

applying a curable resin onto the primary mold to cover the shape and pressing the mold material against the primary mold with the curable resin in between so as to transfer the shape on the primary mold to the curable resin;

curing at least a portion of the curable resin;

separating the curable resin from the primary mold with the curable resin being bonded with

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the mold material; and

transferring the shape on the curable resin
to the mold material by dry-etching to form the mold.

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30. The method as claimed in claim 29,
further comprising a step, before applying the curable
10 resin, of performing a de-molding treatment on the
primary mold to facilitate separation of the curable
resin from the primary mold.

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31. The method as claimed in claim 30,
further comprising a step, before applying the curable
resin, of performing a surface treatment on the primary
20 mold to increase adhesion between the curable resin and
the mold material.

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32. A mold for transferring a shape thereon
to an object material by pressing the object material
against the mold with a curable resin in between to
transfer the shape to the curable resin, curing a
5 portion of the curable resin and transferring the shape
on the curable resin to the object material, the mold
comprising:

a channel for an uncured portion of the
curable resin surrounding the cured portion of the
10 curable resin to flow in to fill in a space generated
due to shrinkage of the curable resin during curing.